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AUTHOR Nagy, Kristin; Collins, Angelo; Duschl, Richard; Erduran, Sibel

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ABSTRACT

Consistent with the current reform movement in science education, the purpose of this study was to examine how the introduction of an innovative curriculum influenced teachers' beliefs. Six teachers each implemented an Acids & Bases Curriculum Unit in a variety of middle school settings. The teachers were interviewed regarding their beliefs prior to and after the unit. Using the constant comparative method, triangulation of data, and member checking, a number of themes emerged. This paper focuses on changes in the teachers' beliefs about assessment and the nature of science. Each of the changes in beliefs are correlated with the National Science Education Standards (National Research Council, 1996). The conclusion is that implementation of the Standards through use of an innovative curriculum is progress toward changing teachers' beliefs about assessment and the nature of science, but there are further difficulties associated with establishing reforms in the classroom. (Author/ASK)

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# Changes in Science Teachersí Practice & Beliefs: Progress Toward Implementing Standards-Based Reforms

Kristin Nagy, Angelo Collins, Richard Duschl, & Sibel Erduran

Peabody College, Vanderbilt University

Paper presented at the Annual Meeting of the

National Association for Research in Science Teaching

For information contact: Dept. of Teaching & Learning,

Box 330 GPC, Vanderbilt University,

Nashville, TN 37203

E-mail: **Kristin.m.nagy@vanderbilt.edu**

angelo.collins@vanderbilt.edu

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## Abstract

Consistent with the current reform movement in science education, the purpose of our study is to examine how the introduction of an innovative curriculum influences teachersí beliefs. Six teachers each implement an Acids & Bases Curriculum Unit in a variety of middle school settings. We interview the teachers regarding their beliefs prior to and after the unit. Using the constant comparative method, triangulation of data, and member checking a number of themes emerge. This paper focuses on changes in the teachersí beliefs about assessment and the nature of science. We correlate each of the changes in beliefs with the *National Science Education Standards* (National Research Council, 1996). Our conclusion is that implementation of the *Standards* through use of an innovative curriculum is progress toward changing teachersí beliefs about assessment and the nature of science,

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but there are further difficulties associated with establishing reforms in the classroom.

Changes in Science Teachersí Practice & Beliefs:

Progress Toward Implementing Standards-Based Reforms

Introduction

This paper focuses on three aspects of the current science education reform movement described by the American Association for the Advancement of Science [AAAS], Project 2061(Rutherford & Ahlgren 1989) and the *National Science Education Standards* (National Research Council, 1996). In addition, this paper examines the difficulties and successes associated with implementing these reforms. These three aspects of reform are studentsí understanding of scientific inquiry, assessment of studentsí understanding, and the changing conceptualization of the nature of science. In reporting on key features of the *National Science Education Standards* , Collins stated that "understanding requires a facility in inquiry and a depth of scientific knowledge necessary for application" (1995, p. 32). We describe and analyze one study with science teachers implementing a curriculum unit designed to encourage scientific inquiry and alternative forms of assessment in the context of *Standards-* based reforms. The results indicate that the teachers see the role of assessment and the nature of science as evolving. Elucidating some of the major obstacles in implementing classroom reforms, we discuss recommendations for teachers to help ensure that the reform goals are realized.

The claim that "learning science is something that students do, not something that is done to them" (NRC, 1996, p. 2) emphasizes the essential role of the student in defining his/her own scientific literacy. This student involvement in scientific inquiry combines "processes and scientific knowledge as [students] use scientific reasoning and critical thinking to develop their understanding of science" (NRC, 1996, p. 105). Scientific inquiry includes "asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments (NRC, 1996, p. 105). The broader definition of scientific literacy intermingled with scientific inquiry in all of the science reform documents redefines the very nature of science that all students should experience and come to understand.

The dominant forms of assessment in K-12 classrooms today are tests and quizzes according to Wiggins (1989). He states that teachers generate these types of assessments in order to evaluate individual student performance. These assessment practices generally test for factual recall of specific knowledge. This type of superficial comprehension is inadequate for the communication of studentsí complex understanding of the interconnectedness inherent in science. Furthermore, these one-dimensional modes of assessment are inconsistent with curricular reform efforts and comprehensive, inquiry based science-teaching methods. Although science teachers have been using more authentic forms of assessment like laboratory reports and projects for some time, recently, there has been a call for additional alternative methods of assessment. This call has been facilitated by the climate created by the current educational reform efforts. Alternative assessments need to be designed to authentically assess student understanding. The development of new assessment strategies is essential to the success of reform efforts. Without assessments that examine the complex nature of student understanding, the success of the current reform efforts will not be measurable.

In this study, teachers use a curriculum unit (Duschl & Gitomer, 1997) designed to promote understanding and inquiry through modeling and argumentation in middle grades science classroom. The unit also utilizes a new mode of assessment, called the assessment conversation, in which the teacher selects representative student work samples to initiate classroom discussion of science ideas. One purpose of the research reported here was to analyze how implementation of the unit influenced teachersí beliefs regarding science teaching, student understanding, the nature of science, and the role of assessment. This paper focuses on two major aspects of change in the teachersí beliefs. These areas encompass assessment and the nature of science. We also examine how these changes in teachersí beliefs coincide with obstacles to establishing *Standards* based reforms in the classroom.

## Methods

### Description of the Acids & Bases Curriculum Unit.

The Acids & Bases Curriculum Unit was written by researchers (Duschl & Gitomer, 1997; Erduran & Duschl, 1995;Smith, 1995; Schauble et al., 1994) and a group of teachers beginning in 1993 and has undergone numerous revisions. The Acids & Bases Curriculum Unit is part of Project SEPIA (Science Education through Portfolio Instruction and Assessment) and has been supported by the National Science Foundation and the Department of Education, Office of Educational Research and Improvement. Project SEPIA investigates curriculum, instruction, and assessment models that put an emphasis on epistemological, representational, and cognitive goals of science learning (Duschl & Gitomer, 1997; Erduran & Duschl, 1995;Smith, 1995; Schauble et al., 1994). The project broadens the idea of the content of science from its conceptual basis to include the processes that generate the evidence, and the criteria, rules and standards used to evaluate scientific observations and knowledge claims. Between 1993-1997, the unit has been implemented in 15 classrooms in 14 schools in three states.

Teachers, researchers and advisors working on Project SEPIA believe this learning environment approach proceeds from five key design features: (a) The topic of investigation is an authentic question or problem that has some consequence to the lives of the children; (b) Conceptual goals are kept to a limited number to facilitate an understanding and adoption of criteria that assess the accuracy and objectivity of knowledge claims; (c) Assessment of studentsí understandings and ideas proceeds from assignments that by design produce a diversity of outcomes; (d) Both the criteria for the assessment of studentsí products and performances and the products and performances themselves are publicly shared, employing a teaching discourse/feedback strategy labeled as ëassessment conversationí; (e) The depth of student understanding is assessed and communicated employing a portfolio process. Together, these five principles contribute to the design of a learning environment that promotes science as inquiry and develops studentsí understanding about scientific inquiry, both elements of student learning important in the *National Science Education Standards*.

The Acids & Bases Curriculum Unit is a performance-based unit in which the main problem-solving tasks are the identification of unknown substances, and the generation of strategies for their proper disposal. The problem-solving tasks necessitate the formulation, evaluation and revision of chemical models that explain the physical and chemical properties of acids and bases. The unit lasts about five weeks and consists of activities that encourage the generation, refinement and validation of several types of models (e.g. symbolic, physical, pictorial models). Throughout the unit students carry out experiments, construct models of acids and bases based on evidence from experiments, publicly articulate their results, and engage in whole class discussions and arguments for evaluating their models. Students keep a record of their investigations in the form of storyboards and written reports. These reports are assessed, refined and revised on an ongoing basis using modeling criteria.

Overall, the curriculum unit promotes studentsí argumentation about properties of matter, within the context of physical and chemical properties of acids and bases, and changes in matter, within the context of neutralization reaction between acids and bases which results in the formation of new substances (i.e. salt and water). The unit has knowledge, reasoning, and social goals. Knowledge goals engage students in the evaluation of claims on evidence and how evidence relates to model building. Reasoning goals target improvement of studentsí cognitive and metacognitive skills. Social goals aim to develop studentsí communication and representation skills in science.

The *Acids & Bases Curriculum Unit* is the centerpiece for the study. Six teachers who were previously involved in implementing changes consistent with the current reform efforts were selected to participate in the research project. Two of the teachers were experienced with project SEPIA. Three of the teachers participated in Science for early adolescent teachers. One of the teachers was involved with Schools for thought. All six teachers were

experienced middle grades science teachers from a range of school settings including both rural and urban locations in three different states.

The teachers attended a two-day workshop that focused on instructional aspects of the unit prior to beginning the unit. During this time, the university researchers interviewed the teachers. The teachers were also interviewed after the implementation of the *Acids & Bases Curriculum Unit* . Both the pre and post unit interviews were conducted using an open-ended protocol (see Appendix). The interviews were audio taped and transcribed.

The interview data was analyzed using the constant comparative method, triangulation of data, and member checking. Numerous themes emerged during the course of the analysis. Two of these themes include the role of assessment and the nature of science in the classroom. In this paper, we further analyze and explore these two themes.

## Results

### Changes in assessment practices.

Involving these teachers in a unit designed for curricular, teaching, and assessment changes subsequently alters their traditional definitions of assessment and their perception of the nature of science. Traditional modes of assessment focus on correctness, have a summative nature, and the purpose is to assign a grade. In contrast, Stiggins (1994) asserts that new modes of assessment focus on understanding, argumentation, and modeling. These newer modes of assessment occur throughout the Acids & Bases unit, and the main purpose is to check for student understanding and daily revise the curriculum and teaching. Newer modes of assessment also establish the criteria for success with the students prior to the actual assessment.

Before beginning the unit, teachers prepared written comments about assessment. Steve states, "Iím not sure if I can honestly say how a student should be assessed. I know what I do now is not so much an assessment of knowledge gained as it is an assessment of work produced.... This is not really measuring intellectual growth or learning." This comment indicates that Steve is dissatisfied with his current modes of assessment. Terry contends that assessment is, "very difficult especially when attempted traditionally. You canít really assess non-traditional teaching methods with traditional test which presents a problem." In his statement Terry identifies the inadequacy of traditional assessment modes for non-traditional classrooms. Angie asserts that, "learning goals and assessment criteria should always be clearly articulated to students. Assessments should be closely aligned to the learning goals and should be varied." Angie elucidates the broad nature and purpose of assessment as she sees it. The pre-unit ideas about assessment ranged from expressing dissatisfaction with current and traditional modes of assessment to an abstract understanding of alternative forms of assessment.

After the unit, teachers report numerous changes in their beliefs about assessment as well as their actual assessment practices. The six teachers with whom the research team worked with experience a sense of dissatisfaction with traditional modes of assessment. Jeff communicates his belief that science assessment should not only focus on correctness. Frank suggests that the studentsí use of individualized models in this unit is a successful tool in science learning and assessment. Both of these suggestions are congruent with Assessment Standard B in the *National Science Education Standards* which "portrays the outcomes of science education as rich and varied." (NRC, 1996, p. 79)

In a post interview Jeff states, "that there has to be new and different expressive ways to show understanding. Especially since science is not simply a bantering of facts....In science, I think it is very possible for a student to follow a good scientific process of thought and not come up with the exact same idea that I hold to be true. I donít know that I want everybody to come up with the same idea on every single concept. The process sometimes is more important than the end result.... There is a healthy degree of variance within a science classroom and there needs to be a healthy degree of variance in how you assess that. ... There needs to be a chance for students to express the extent to which they understand something." (Interview 6-29-97)

Frank comments during a post unit interview, "Where if the students are given the opportunity to submit their own model of whatever is an acid without fear that their model is going to be evaluated for a grade and that the student can revise their model as they go along then that goes a long way to providing better understanding for the student. Because they have to go through what they think they know and they have to go through it in some way and become comfortable enough with their understanding to take it from the concept that they have running around in their head and put it on a piece of paper in their own way. Whatever way that is. And I think that kind of

goes under the last questions that we were discussing about the role of the teacher in the science classroom and the changes in science. A school pretty much doesnít want students to think. They want them to do everything the same way. And yet when they graduate from school they want people who can think." (Interview 6-29-97)

Wanda and Angie elaborate on the less cumulative nature of assessment. They emphasize the inherent link between assessment and adjusting teaching and learning goals. This relates to Teaching Standard C which uses "student data, observations of teaching, and interactions with colleagues to reflect on and improve teaching practice." (NRC, 1996, p. 38)

Wanda asserts in her post unit interview, " So, I see assessment now as a whole. Not as the end. You know, you usually see assessment as the end. Okay, this is the end. What did they learn? Now I see it as everything along the way. I am sort of gathering information in my head as to what they are learning. It helps me to guide them if I have to go back and re-teach something. Because there were times that I had to reteach a particular thing or put more emphasis upon something because I found they have some confusion about it. In my opinion all of that is assessing. It is not necessarily just giving a grade each time. It is just assessing what is going on and guiding them so that they are very clear about what is going on." (Interview 6-29-97)

Angie states during her post unit interview, "I believe that good teachers are constantly assessing. That informal assessment is more important to me... as far as driving what a teacher does than formal assessments. What is real important is giving kids feedback to enhance their learning. Just looking at producing... evaluation... producing some judgment of what a kid knows or understands...But probably one of the best ways is to have a plan for doing it and that involves collecting the papers and looking at them, which oneís you want to present and talk about, why you want to present those, what you really want the kids to look at and so on." (Interview 6-29-97) In this quotation, Angie is referring to the assessment conversation in which specific works are selected and presented to the class.

Terry discusses the changing purpose of assessment. This change in purpose has to do with the inferences made about understanding from assessments. This relates to Assessment Standard E from the *National Science Education Standards* which states that, "the inferences made from assessments about student achievement and opportunity to learn must be sound." (NRC, 1996, p. 86)

During his post unit interview Terry says, "First, I think that I should say that I donít know what my beliefs about assessment are anymore. ... Assessment itself is a hard thing. By teaching this unit my beliefs in assessment certainly have changed because youíre assessing what you can see. What you see being presented to you....When a parent comes in to check on a kidís grade you canít say, well... you know, he did put forth for a B here as you can see through this portfolio. No, they want to see numbers. In that regard my ideas of assessment have changed. I donít know if they have changed because I have never really enjoyed number assessment, paper and pencil testing. But certainly... I have thought a lot more about it. I have had to because of this unit and how I would go about assessing a studentís progress. This is more of a progress thing as opposed to a number. Like I said before it is a lot more fair to the student but at this point in time a little more work for the teacher." (Interview 6-29-97)

After describing their changes, the teachers talk about the need for new modes of assessment and models of how to assess student understanding. This idea relates to Assessment Standard A in that "assessments must be consistent with the decisions they are designed to inform." (NRC, 1996, p. 78)

During his post unit interview Frank states that, "My ideas of assessment are changing. It has changed over and over. But it is to the point now where different types of assessment like authentic assessment and things like that [are present], areas that I wouldnít feel very comfortable in because I am just foreign to them. It confirms that if we are going to move education in this direction... this type of learning... then there has to be other kinds of assessment. So, I think the confirmation is that my idea is that assessment needs to change, but I am not sure how. But it needs to change and this shows that you really canít use the old type of assessment in this type of a learning atmosphere or it wouldnít be very effective." (Interview 6-29-97)

Steve acknowledges during his post unit interview that, "I would love to be able to put more ideas of how to evaluate works as truly problem solving and logical thinking kind of things or have them to come up with enough thinking habits to make me feel content that what I am doing is truly measured. It is a struggle for me. It is an evolving thing and with this project we are starting with the portfolio... I somehow got this portfolio grading thing... donít use traditional method of grading... then it was suddenly thrust upon me that I have to work out some of these things for myself, and I donít feel like I am doing a very good job because I didnít have enough of the tools

because it was something that was new to me." (Interview 6-29-97)

After the unit, teachers express ideas that indicate changes in beliefs, practices, and understanding of assessment. They believe that assessment should not focus solely on correctness. They also assert that there needs to be some individualization of assessment modes. The essential link between teaching and assessing is evident to the teachers as well as the changing purpose of assessment. Finally, the teachers express a need for new types of assessments. These ideas are encompassed in the *National Science Education Standards* in Assessment Standards A, B, and E as well as Teaching Standard C. The correlation between the teachersí changing beliefs and the specific standards emphasizes the progress toward the implementation of the *Standards* .

The evolving nature of science

In relation to the changing role of assessment, the teachersí pre-unit comments regarding the nature of science indicate changes from their post-unit interviews. Prior to the unit, the teachers assert that science is a way of looking at the world. This view encompasses a logical discovery and problem-solving approach during which scientists are actively engaged in discovery. For example Frank states, "I believe that science is our way of trying to understand the world as we perceive it. We ask questions about why something behaves like it does and then logically go through steps to explain our observations of the condition we question."

The pervasive undertone in the six teachersí post-unit interviews is that their understanding of the nature of science is changing. These changes have taken many different forms that affect the teacher and the student. Science is a continual process not a stagnant entity. This concept is directly related to the science Content Standard about science as inquiry. "The new vision includes the processes of science and requires that students combine processes and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science." (NRC, 1996, p. 105).

Jeff states during his post unit interview that, "I think in science... thatís all that any of us are doing. We are just expressing the extent to which we understand acid and bases in this case. This is not saying that we know everything that there is to know. That is not saying that we are authoritatively stating the facts about acids and bases. We are saying that this is what present day understanding has lead to. Someday we will go beyond this... because science is constantly being rewritten... because it has so much of a process identity it needs to be assessed in ways that can really capture that." (Interview 6-29-97)

Modifying the goal of science from factual recall to problem solving is embodied in Teaching Standard A. This standard states that teachers "select teaching and assessment strategies that support the development of student understanding and nurture a community of science learners." (NRC, 1996, p.30)

In her post unit interview Wanda states, "Children in my opinion also feel that there is that end answer. So you have to reassure them they will be able to put all of this together and it will make sense... It is what you have discovered. It is what you have learned in a group, as an individual and as a class. When you put all that together see what it looks like. See if you found what you are looking for. See if you are able to make the puzzle fit. Because it is like a big puzzle and the pieces are all jumbled up and they are getting bits and pieces of it and they are seeing more and more of the picture as they go along. And when they finish there is this big brilliant picture in front of them."(interview 6-29-97)

To summarize, science is a process to answer why.

Steve interjects during his post interview, "But when you are talking about science you are talking about the why and being able to figure out a way to answer the question. That really answers that question. When you solve that dilemma of a problem you go to the next part and pick another why." (Interview 6-29-97)

Exploration and investigation are an essential component of science. These ideas are put forth in Teaching Standard D. This standard asserts that teachers should "structure the time available so that students are able to engage in extended investigation." (NRC, 1996, p. 43)

Angie says during her post unit interview that, "I see the importance of a well organized curriculum that provides students experiences that lay a foundation for further learning and it reinforces my belief that elementary school science is extremely important. And this is a place where kids should be doing a lot of active exploring and getting

a lot of experiences and that is still very important in middle school too. And in high-school hopefully those experiences then would have prepared them for a lot more in the way of abstract learning and book work and so on and so forth. But also the organization of the content is important too. The idea of just throwing things to kids without having any respect for what they already know... it is not necessarily a bad thing to do if it is good science. This to me was an example of good science. And even though the kids didnít get everything from it that they might have if they had an understanding... like I said... they still... it gives them a little something up here to wonder about that... it is a teaser... it is an appetizer for something more to come." (Interview 6-29-97)

Science is communicating with the public and with peers. This notion of a scientific community is encompassed in Teaching Standard E. It states that teachers should "structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse." (NRC, 1996, p. 46)

In the post unit interview Steve says, "And not just share it as a fact but to give you the evidence and say that here is the evidence that shows it is true and unless you show me evidence that makes this not right then I have to support this as the idea because I have the evidence. A lot of that is what science is. Getting the information and presenting it and convincing others that that is what you believe. You can have the Theory of Relativity but no one else knows about it or not one else can understand it and you canít explain it...then you really donít have science... you are the only one who knows it... you are not sharing it... it is not being accepted by anyone else... it doesnít help anyone else and in a sense that is what science tends to be... things that help people... answers those why questions that a lot of people are not ---- that you want a solution." (Interview 6-29-97)

Associated with the teachersí change in beliefs about science are changes in studentsí perceptions. The students have more ownership of the unit. This student ownership is elucidated in Teaching Standard E. According to the standard, teachers should "enable students to have a significant voice in decisions about the content and context of their work and require students to take responsibility for the learning of all members of the community." (NRC, 1996, p. 46)

Frank asserts in his post unit interview "I think because of the method of learning and the idea of what we have of learning especially learning in science has changed. I think the role of the teacher has to change to fit that concept of learning. And because we are not... the unit is perfect for that because it is mostly student driven as opposed to teacher directed." (Interview 6-29-97)

Different students struggle or succeed with the changing nature of science. This idea pertains to Teaching Standard A which states that teachers should "select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students." (NRC, 1996, p. 30)

Jeff comments during his post unit interview that, "One other issue that came out that really shocked me to death was students who didnít feel that they were learning as much as they had in other science classes because they didnít have this list of vocabulary words that they had learned to define and spell and they couldnít rattle off a bunch of facts that really meant nothing. A bunch of facts that in all honesty that wasnít really [of any] value when you compare them to the bigger concept or the process." (Interview 6-29-97)

In her post unit interview, Wanda says "I heard all sorts of things from my kids as far as pros and cons about the unit but I can truly say that they all feel that they learned something. They all feel that they learned something. Some kids seem to think that they havenít learned as much." (Interview 6-29-97)

During his post unit interview Terry states "I have said many times that this program takes the middle C type students and gives them a chance to really show off a little. Some of these kids have always been C students but they have been so much more and this gives them the opportunity to say, well I saw this happening so therefore it happened and I am allowed to talk about it happening... I mean there is no right or wrong there... it happened... this is what I am telling you happened when I did this test. I like the way thatís set up because the student has created the result. It is as if they can say ----. I am not giving you an answer to a question. I am just giving you information that I have right in front of me that I tabulated that I saw and I want to offer it up. I will offer you this if I am allowed to take that. It is a neat and unique opportunity. They feel like they are sharing and they are. They are giving each other what it is that they need to succeed." (Interview 6-29-97)

In summary, the teachersí beliefs regarding the changing nature of science involve seeing science as a continual process not as a fixed body of knowledge or stagnant. A similar shift involves seeing the goal and focus of science as one of problem solving. In line with the problem solving nature of science, the teachers believe that exploration



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and investigation are key components of science. The teachers also emphasize the importance of students learning to communicate science with their peers and the public. Another aspect of the changing nature of science has to do with giving the students more ownership of the unit. This shifts the emphasis from teacher directed to student directed. Finally, the teachers realize that different students struggle or succeed with the new science. All of the teachersí beliefs regarding the changing nature of science are found in the Content Standard regarding science as inquiry and teaching standards A, D, and E. The links between the teachersí changing beliefs and the *Standards* is encouraging information regarding the implementation of the *Standards* into the classroom

Conclusions and Recommendations

The Acids & Bases unit was designed to promote student understanding through scientific inquiry and to use a new mode of assessment. Teaching the unit impacts the teachersí beliefs regarding science teaching, student understanding, the nature of science, and the role of assessment. The teachers all express some level of dissatisfaction with the traditional methods of assessing, especially when what is taught does not match the achievements which are measured by traditional modes of assessment. The teachers also articulate a change in the assessment culture that stems from reform-based changes in science teaching through inquiry. These changes in the assessment culture involve shifting the focus from correctness, assessing to inform teaching, and involving students in the assessment process. All of these changes in teachersí beliefs about assessment focus on the necessity and difficulty involved in shifting from traditional to authentic assessments. Furthermore, the teachers realize the need for students to re-conceptualize the nature of science and are struggling with the difficulties associated with this change.

Collins (1995) identifies reasons why implementing the *Standards* would be complex. This complexity is contrasted with the fact that the difficulties are predictable. For instance, Collins anticipates that one of the obstacles to implementing the *Standards* into science classrooms involves the changes surrounding belief and practice. These changes are more substantive and fundamental than changing an activity or a textbook. They require teachers, students, and administrators to reconceptualize their ideas regarding the nature of science. This is not a trivial task. Current beliefs regarding the nature of science are embedded in every aspect of todayís society. However, the six teachers in this paper have begun the process which is necessary and fundamental for these changes to occur.

A practical problem associated with implementation of the *Standards* is that teachers need to have more tools and resources for change. This is a critical issue of professional development for existing and beginning teachers. University teacher educators and experienced teachers have to make a conscious commitment to changing the nature of science which is taught, learned, and assessed. Furthermore, policy makers and test-makers need to be aware of the changing nature of science and design national assessments geared more toward assessing understanding not factual recall. Until all levels of the educational system are invested in the science reform efforts the goals will not be actualized.

Another difficulty is that reforms have primarily occurred in units with a finite number of teachers due to a limited amount of resources. This fragmentation of reformed-based units does not present a comprehensive view regarding the evolving nature of science. In turn, the students are not presented with a unified picture of the nature of science. To fully realize the goals of the standards, reform efforts will need to take on a large-scale, multi grade level approach. This will allow for less confusion and segmentation of studentsí views of the nature of science. The research in this paper suggests that the *Standards* í goals for reforming science are demanding but attainable. Implementing curriculum units designed to promote inquiry is one tool to promote reform. Still, establishing the *Standards* in the classroom has its pitfalls. However, the commitment and desire to change are evident in all six of the teachers. This is the necessary first step in the reform process. The next step is providing teachers and students with the support necessary to facilitate change. This support is critical since the reform goals are attainable in the classroom only when all of the constituents of science education employ their vast resources toward achieving them.

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## Appendix

The goal of this interview is to explore the teachersí beliefs and changes in beliefs in respect to our five research questions:

1. the nature of science
2. how children learn science
3. the role of the student in the classroom
4. the role of the teacher which promotes understanding in the classroom
5. appropriate assessment for student understanding